# Xenon Isotopes Released from Buried Transuranic Wastes

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## RESEARCH OBJECTIVES

This project addresses the Department of Energy need to characterize and assess the location, type, and mobility of wastes in the subsurface. The specific objective is to evaluate the use of xenon isotopes in soil gases to detect the presence of radioactive transuranic wastes, characterize the waste, and model the transport of fission xenon through the unsaturated soil gas environment.

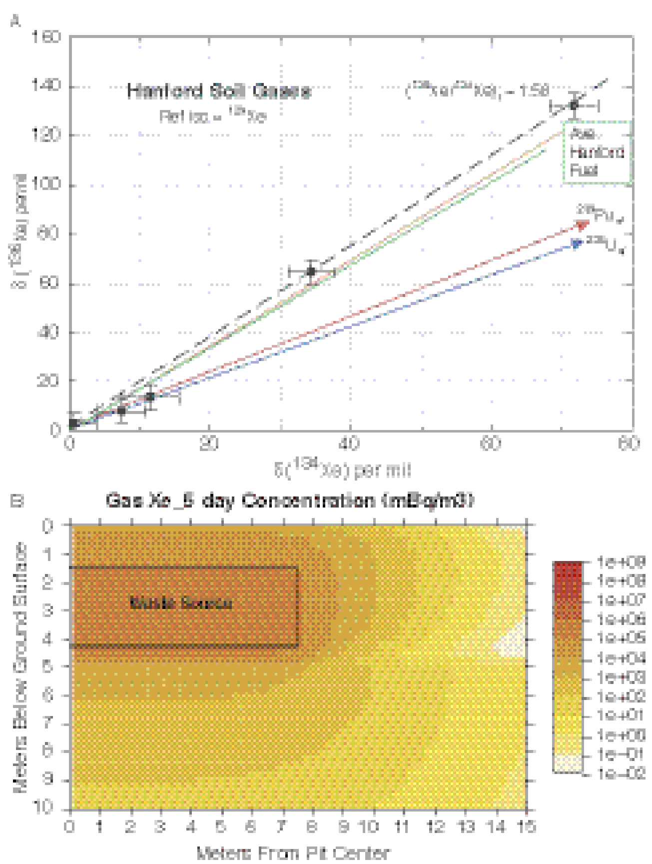


Figure 1. A: Isotopic composition of xenon in Hanford soil gases. Dashed line is a least squares fit to the data. Solid lines represent the composition of various fission sources, including the composition expected for Hanford fuel rods (orange and green lines). B: Modeled distribution of $^{133}$Xe in the vadose zone relative to a waste source and constrained by the the values measured in the soil gases.

## APPROACH

Xenon is a chemically inert noble gas and therefore a conservative tracer under most geologic conditions. Several stable and short-lived radioactive xenon isotopes are produced as fission products in nuclear reactors and through spontaneous fission. The isotopic composition of fission-produced xenon will have a characteristic yield pattern that can be used (1) to detect fission xenon in soil gases saturated with ambient atmospheric xenon, and (2) as a diagnostic tool for characterizing the fission source(s). Presence of short-lived fission xenon isotopes ($^{133}$Xe, $t_{1/2}$ = 5.24 days; $^{135}$Xe, $t_{1/2}$ = 9 hours) in surrounding soil gases would confirm ongoing fission in the buried waste—and (under optimal conditions) could be used to set limits on leakage rates from the buried waste containers, as well as transport and residence times in the soil gas environment.

## ACCOMPLISHMENTS

Initial measurements of soil gases collected near disposal facilities at the U.S. Department of Energy's Hanford site clearly show both stable and radio-xenon isotopic signatures indicative of transuranic waste. The isotopic composition of the stable fission-xenon isotopes closely matches that calculated for production from Hanford's unenriched and enriched Zr-clad fuel (Figure 1A). Radio-xenon isotopes were also detected, and their abundances have been used in a multiphase vadose zone transport model that indicates transport from the waste source is at a sufficient rate to be detected up to 10's of meters away. Additional data will be needed to constrain leakage rates from the waste container.

## SIGNIFICANCE OF FINDINGS

Remediation of buried transuranic and other waste is one of the most difficult and costly environmental issues at U.S. Department of Energy sites. This project addresses the DOE need to characterize and assess the location and mobility of wastes in the subsurface. We have demonstrated that xenon isotopes released to the vadose zone from transuranic wastes provide unique tracers for source identification and the study of vadose zone transport processes, as well as having potential for constraining leakage rates from buried containers.

## RELATED PUBLICATIONS

Dresel, P.E., and S.R. Waichler, Evaluation of xenon gas detection as a means for identifying buried transuranic waste at the Radioactive Waste Management Complex, Idaho National Environmental and Engineering Laboratory. PNNL-14617, Pacific Northwest National Laboratory, Richland, Washington, 2004.

Dresel, P.E., S.R. Waichler, B.M. Kennedy, J.C. Hayes, J.I. McIntyre, J.R. Giles, and A.J. Sondrup, Xenon isotope releases from buried transuranic waste. Trans. Am. Geophys. Un., Fall Meeting, San Francisco, CA, 2005.

## ACKNOWLEDGMENTS

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